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Non-operating room anesthesia in children undergoing interventional cardiac procedures

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Abstract

Aim: With advances in medical technology in the last decades, diagnostic and therapeutic interventional procedures are increasingly being applied in the pediatric population. Those procedures are frequently performed under non-operating room anesthesia. The aim of this study was to report our non-operating room anesthesia experience of interventional cardiac procedures in the pediatric population.

Material and Methods: Retrospective analysis of 156 patients who underwent interventional cardiac procedure under non-operating room anesthesia was conducted.

Results: All procedures were performed under general anesthesia using an endotracheal tube (85.9%) or laryngeal mask (14.1%). The two airway instruments were similar in complication, total hospitalization time, and need for a pediatric intensive care unit. There were no differences in complication, total hospitalization time, and need for a pediatric intensive care unit between the patients who were administered neuromuscular relaxant and those without neuromuscular relaxant. Among the patients who were administered neuromuscular relaxant, there were no differences in complication, total hospitalization time, and need for a pediatric intensive care unit between patients receiving sugammadex and those not using a neuromuscular blockage antagonist.

Discussion: The laryngeal mask can be used as safely as an endotracheal tube in pediatric interventional cardiac procedures under non-operating room anesthesia. Propofol plus remifentanil with or without rocuronium is a suitable combination for induction of anesthesia. Sugammadex is a reliable option in reversing the neuromuscular blockage.

Keywords

Cardiac procedure; Interventional; Non-operating room; Pediatric anesthesia

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Introduction

With advances in medical technology in the last decades, diagnostic and therapeutic interventional procedures are increasingly being applied in the pediatric population with cardiac diseases such as atrial septal defects (ASD), ventricular septal defects (VSD), and patent ductus arteriosus (PDA) [1]. As known, these interventional procedures are frequently performed in specific places outside the operating theater. Therefore, non-operating room anesthesia (NORA) techniques have gained popularity in daily practice. However, NORA has several challenges including unfamilarity with the environment, possible lack of drugs and equipments, exposure to radiation, and limited help from other anesthesiologists [2,3]. There are also risks specific to the pediatric patient group, such as different disease patterns, different dosages of the drugs, and different equipments. Moreover, those children usually have abnormal cardiac structure and function; therefore, extra clinical attention is of great importance for an accurate perioperative evaluation.

In this study, we aimed to report our NORA experience of interventional cardiac procedures (ICPs) in pediatric patients and discuss the outcomes with the relevant literature.

Material and Methods

General Data

Retrospective analysis of 156 patients (aged 1-18 years) who underwent ICPs (ASD, VSD, PDA, and etc.) under NORA between 2015 and 2018 was conducted. This study was approved by the Research Ethics Committee of Osmangazi University (permit no: 17.04.2018-4) and was performed in accordance with the Declaration of Helsinki. Patients' demographic data including age, gender, and weight, preoperative diagnosis, American Society of Anesthesiologist (ASA) scores, and all anesthetic techniques were recorded.

Anesthesia Management

The catheterization laboratory was heated. A heater blanket was also placed on the operating table. Standard monitoring included a five-lead electrocardiogram (ECG), noninvasive blood pressure, pulse oximetry, and invasive pressure monitoring after the placement of femoral catheter sheaths.

All patients were operated under general anesthesia. Induction of anesthesia was performed with IV remifentanil (0.5-1 mcg/kg) + lidocaine 0,5 mg/kg + propofol (3-5 mg/kg) + inhalation sevoflurane (% 2-3) in an 4 L/min air (50%) and oxygen (50%), with or without rocuronium (0.3-0.4 mg/kg). After adequate neuromuscular blockade, airway control was provided by endotracheal tube or laryngeal mask. Anesthesia was maintained with sevoflurane (% 2-3) in air-oxygen mixture (FiO2:0.4). During anesthesia, remifentanil infusion (0.1 mcg/kg/min) was added when needed. Additional drugs such as atropin, adrenalin, prednisolone, diphenhyidramine, and antiarrhythmic were administered to the patients when needed. The reverse was done using sugammadex (2-4 mg/kg, with titration) in patients who were administered neuromuscular blocking agent. Paracetamol 10 mg/kg (IV or rectal) was given to all patients for postoperative analgesia. At the end of the procedure, the patients were followed-up in the recovery room for at least half an hour or were transferred to the intensive care unit (ICU) of pediatric cardiology or inpatient clinic.

Statistical Analysis

The Statistical package for social science (SPSS 20.0 software, IL-Chicago-USA) standard version was used for data analyses. Descriptive analyses were presented as number/percentage for categorical variables, and mean±SD/percentages for continuous variables. The Chi-square test, Mann Whitney U test, and Fisher's exact test were used to evaluate the differences between the patient groups. $P<0.05$ was accepted as the significance level.

Results

A total of 156 patients with a mean age of 6.8 years were included in the study. There were 88 (56.4%) females and 68 (43.6%) males. The most common diagnoses were ASD (n=64, 33.8%), PDA (n=41, 21.7%), and VSD (n=34, 18%). Some patients had more than one diagnosis; therefore, a total of 189 interventional procedures were performed. All procedures were performed under general anesthesia using an endotracheal tube (n=134, 85.9%) or a laryngeal mask (n=22, 14.1%).

Table 1. Demographic and clinical characteristics of the patients (n=156)

Characteristics	n (%)
Age (y)	6.8±4.8 (1-18)
Gender (Female/Male)	88 (56.4%)/68 (43.6%)
Weight (kg)	24.1±16.4 (4-110)
Diagnosis*	
ASD	64 (33.8%)
PDA	41 (21.7%)
VSD	34 (18%)
Others**	32 (17%)
ASA score	
ASA1-2	137 (87.8%)
ASA3-4	19 (12.2%)
Duration of the procedure (min)	91±35.1 (26-190)
Duration of anesthesia	96.9±35.5 (30-195)
Airway instrument	
Endotracheal tube	134 (85.9%)
Laryngeal mask	22 (14.1%)
Induction	
Propofol+Remifentanil+Sevoflurane	79 (50.6%)
Propofol+Remifentanil+Sevoflurane+Rocuronium	77 (49.4%)
Maintenance of anesthesia	
Sevoflurane alone	139 (89.1%)
Sevoflurane plus additional anesthetic drug	17 (10.9%)
Reverse	
None	125 (80.1%)
Sugammadex	31 (19.9%)
Complication	
Arrhythmia	8(5.1%)
Laryngospasm/bronchospasm	7(4.4%)
Others***	3(1.9%)
Hospitalization time (d)	2.7±1.8 (1-13)
Need of ICU	10 (6.4%)

Data are presented as mean±SD for age, weight, duration of procedure, duration of anesthesia, and hospitalization time; n (%) for other variables. y: year, kg: kilogram, min: minute, d: day, *Some patients had more than one diagnosis, **Coarctation of the aorta, tetralogy of fallot, mitral stenosis, pulmonary stenosis, and transposition of the great arteries, ***Two mild allergic reaction and one hypotension

Table 2. Comparison of patients with endotracheal tube (ETT) and those with laryngeal mask airway (LMA)

characteristics	patients with ETT (n=134)	Patients with LMA (n=22)	p
Age (y)	6.8±4.8 (1-19)	6.8±4.9 (1-17)	0.955
Gender (Female/Male)	77 (57.4%)/57 (42.6%)	11 (50%)/11 (50%)	0.644
Weight (kg)	24.6±17.1 (4-110)	21.1±11.3 (7-42)	0.582
Diagnosis*			
ASD	55 (41.1%)	9 (40.9%)	0.314
PDA	36 (26.8%)	5 (22.7%)	
VSD	29 (21.6%)	5 (22.7%)	
Others**	26 (19.4%)	6 (27.3%)	
ASA score			
ASA1-2	117 (87.3%)	20 (90.9%)	0.268
ASA3-4	17 (12.7%)	2 (9.1%)	
Duration of procedure (min)	91.7±33.4 (35-190)	86.4±44.6 (26-175)	0.254
Duration of anesthesia (min)	97.8±33.9 (40-195)	91.5±44.8 (30-180)	0.233
Complication			
arrhythmia	5 (3.7%)	3 (13.6%)	0.722
laryngospasm/bronchospasm	6 (4.4%)	1 (4.5%)	
Others***	3 (2.2%)	0	
Hospitalization time (d)	2.7±1.9 (1-13)	2.4±0.9 (1-5)	0.960
Need of ICU	8 (5.9%)	2 (9.1%)	0.634
Duration of ICU stay (d)	1.1±0.3 (1-2)	1±0 (1)	0.617

Data are presented as mean±SD for age, weight, duration of the procedure, duration of anesthesia, hospitalization time, and duration of ICU stay; n (%) for other variables. y: year, F: female, M: male, kg: kilogram, min: minute, d: day, *Some patients had more than one diagnosis, **Coarctation of the aorta, tetralogy of fallot, mitral stenosis, pulmonary stenosis, and transposition of the great arteries, ***Two mild allergic reaction and one hypotension

Induction of anesthesia was performed with propofol + remifentanil + sevoflurane in all patients. Approximately half of the patients (n=77, 49.4%) were given neuromuscular relaxants. Sevoflurane was used as an anesthetic agent in the maintenance of anesthesia in all patients. The reverse was done in 31 (19.9%) patients. Perioperative complications, most of which were arrhythmia 8(5.1%) and laryngospasm/bronchospasm 7 (4.4%), were observed in 18 (11.5%) cases. No hospital mortality was seen. At the end of the procedure, almost all patients (n=153, 98%) were successfully extubated. All the baseline patient characteristics and clinical features are presented in Table 1.

Patients with laryngeal mask airway (LMA) were compared with those intubated using an endotracheal tube (Table 2). The two airway instruments were similar in all parameters such as complication (p=0.722), total hospitalization time (p=0.960), and need for ICU (p=0.634).

There were no differences in complication (p=0.138), total hospitalization time (p=0.692), and need for ICU (p>0.05) between the patients who were administered neuromuscular relaxant and those without neuromuscular relaxant.

Among the patients who were administered neuromuscular relaxant (n=77), the patients who used neuromuscular blockage antagonist (sugammadex) were compared with those who did not use a neuromuscular blockage antagonist. No differences in complication (p=0.749), total hospitalization time (p=0.674), and need for ICU (p=0.347) were found between these patient groups.

Discussion

Since the first cardiac catheterization was introduced by Werner Forssmann in the 1920's, today many complex ICPs are increasingly performed in special laboratories outside the operating theater [4]. The success of these procedures is directly associated with appropriate anesthetic management. Sufficient knowledge of the characteristics of the interventions, complete preparation of laboratory equipment, and detailed preoperative evaluation of the patients are the key factors for successful anesthesia management. This situation is especially important in children with congenital heart disease because they often have accompanying anatomical and physiological disorders. Such disorders are critical in choosing the optimal anesthesia techniques for the patients [5].

Although anesthesia technique depends on the type and duration of the procedure, general anesthesia is preferred in the majority of patients; because, these cardiac catheterizations are usually performed in the supine position and require complete immobility of patients [6,7]. Sedation may be another choice of anesthesia; however, it carries a risk of an unprotected airway when performed without endotracheal intubation. There are several studies that indicated the safety of deep sedation in the pediatric population who underwent cardiac catheterization for congenital heart diseases. For example, Hanslik et al reported high success and low complication rates in their patient group who underwent transcatheter ASD closure under deep sedation by using ketamine and propofol [8]. However, general anesthesia with endotracheal intubation was the main anesthetic method in the majority of similar clinical studies [1,6,9]. Hamid reported that the decision on the anesthetic technique should be made by attending anesthesiologists in consultation with cardiologists. The author also indicated that general anesthesia is the primary technique especially in critically ill patients, prolonged procedures, uncooperative patients and in procedures that require transesophageal echocardiography [2]. In our clinic, general anesthesia with endotracheal intubation was the main choice of anesthetic technique in pediatric patients if there was no other specific indication. We also used LMA in selected patients, with good outcomes. Since LMA can be easily placed without using muscle relaxants and provides a safe airway, it is now becoming more common in pediatric surgical interventions. Additionally, hemodynamic and intraocular pressure changes are less compared to the endotracheal tube [10]. Moreover, the incidence of desaturation, laryngospasm, cough, and breath-holding during recovery from anesthesia was lower in LMA usage than in endotracheal intubation [11]. Although aspiration of stomach content is an important limitation of LMA use, this risk can be reduced by providing adequate starvation and effective treatment of gastro-esophageal reflux before the procedure. In our study, there was no significant difference in the development of complication between the two airway instruments. We believe that close communication with cardiologists is of great importance in the decision on airway management in patients. Non-complex and short-term procedures, the presence of good preoperative hemodynamic parameters, the absence of pulmonary hypertension, and the absence of diseases with decreased pulmonary compliance such as bronchial asthma were the main criteria in the selection

of LMA anesthesia. Regardless of airway management types, anesthesiologists should give their maximum attention to the hemodynamic effects of the drugs used during the procedure.

Although a variety of pharmacologic agents are available for sedation or anesthesia in pediatrics, propofol and ketamine are the most used drugs in the induction of anesthesia [8,12]. Propofol is generally used in such procedures due to its short duration of action whereas ketamine is preferred by some anesthesiologists because of its sedative and analgesic effects and the lower risk of hypotension and bradycardia. Cardiac depressant effects are the leading disadvantages of propofol use while prolonged recovery time, potential effects on pulmonary vascular resistance, and the risk of delirium are the limitations of ketamine use [2,7]. The combinations of propofol/ketamine or propofol/dexmedetomidine were also recommended by some authors [13-16]. Nitrous oxide should be avoided because of the potential to increase intravascular bubble size [17]. In our routine practice, propofol plus remifentanil was the choice of induction with or without a neuromuscular blocking agent. There were no differences in complication rate, ICU stay, and total hospitalization time between the two induction protocols. Remifentanil which has a fast clearance and short half-life also provides good analgesia and sedation. It can be used safely in newborns and infants thanks to its metabolism independent from hepatic and renal mechanisms [18].

Anesthesia is usually maintained by the administration of sevoflurane alone or with an additional drug including remifentanil infusion [19]. Similarly, we safely used sevoflurane with or without remifentanil in the maintenance of anesthesia. The reverse was done by administration of sugammadex in patients who were given a muscle relaxant. No differences were found between the patients who used sugammadex and those who did not use neuromuscular blockage antagonist in terms of complication rate, length of ICU of pediatric cardiology stay, and total hospitalization time. Therefore, we think that sugammadex can be safely used as a reverse agent in appropriate patients.

Our complication rate seems to be relatively higher compared to similar studies [5,7,20]. However, it should be stated here that not only anesthesia-related complications but also procedure-related complications were recorded in the present work. The most common complications were arrhythmia and laryngospasm/bronchospasm, as were in other studies [5,7,8]. These complications were successfully treated with proper medications. No major complications including air embolism, thrombus formation on device or applicator, embolization of the device, and pericardial haemorrhage or tamponade were observed. There was also no mortality in our patient cohort.

Conclusion

LMA can be used as safely as endotracheal intubation in pediatric ICPs under NORA. Our observations also suggest that propofol plus remifentanil with or without rocuronium is a suitable combination for the induction of anesthesia. Sugammadex is a reliable option in reversing the neuromuscular blockage. Finally, detailed preoperative evaluation, closed perioperative monitorization, and appropriate anesthetic techniques are of great importance for good outcomes in such pediatric ICPs under NORA.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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